Population dynamics of Caspian Kutum, *Rutilus frisii kutum* (Cyprinidae) in southern Caspian Sea, Iran

by

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ABSTRACT. - The population dynamics of Caspian Kutum, *Rutilus frisii kutum* (Kamensky, 1901), sampled from commercial beach seine catches from the southern Caspian Sea (Iran), was investigated. A random sample of 1,360 fish, representing a wide range of fish size (20 to 58 cm FL), was collected from early October 2006 to middle of April 2007. Length-frequency analyses and FiSAT software were used to study the population dynamics. The values of the von Bertalanffy growth function fit to size-at-age data were: $L_\infty = 59.85$ cm fork length (FL), $K = 0.27$ yr^{-1}, $C = 0.25$, WP (winter point) $= 0.40$. Using the seasonalized length converted catch curve, the instantaneous total mortality coefficient Z was estimated as 1.28 yr^{-1}. The instantaneous natural mortality coefficient M was 0.46 yr^{-1}, while the instantaneous fishing mortality coefficient F was 0.82 yr^{-1}, giving the current exploitation rate $E = 0.64$. The mean length at first capture L_c estimated from the analysis of probability of capture of each length class was 36.8 cm FL. The maximum exploitation rate E_{max} predicted from the relative yield per recruit analysis was 0.76, while the current exploitation rate E is less than E_{max}. This indicates that Caspian Kutum is moderately exploited in the southern Caspian Sea.

RÉSUMÉ. - Dynamique des populations du Kutum caspien, *Rutilus frisii kutum* (Cyprinidae) en mer Caspienne méridionale, Iran.

La dynamique des populations du Kutum caspien, *Rutilus frisii kutum* (Kamensky, 1901), a été étudiée à partir d'individus capturés à la senne commerciale dans la partie méridionale de la mer Caspienne (Iran), entre octobre 2006 et avril 2007. Un échantillon aléatoire de 1360 poissons, représentant un large éventail de tailles (20-58 cm de longueur à la fourche : FL), a été étudié. Des analyses de fréquences de longueurs, traitées par le logiciel FiSAT, ont été utilisées pour étudier la dynamique des populations de cette espèce. Les valeurs des paramètres de croissance de von Bertalanffy, adaptés aux données de longueur selon l'âge, étaient : $L_\infty = 59{,}85$ cm (FL), $K = 0{,}27$ an^{-1}, $C = 0{,}25$, WP (point d'hiver) $= 0{,}40$. En utilisant la courbe saisonnière des longueurs à la capture, le coefficient total de mortalité instantané Z a été estimé à 1,28 an^{-1}. Le coefficient de mortalité instantané naturel M était de 0,46 an^{-1}, alors que le coefficient de mortalité instantané par pêche F était de 0,82 an^{-1}, ce qui a donné un taux d'exploitation courant $E = 0{,}64$. La longueur moyenne à la première capture L_c, estimée par l'analyse de probabilité de capture de chaque classe de taille, était de 36,8 cm (FL). Le taux d'exploitation maximum E_{max}, prédit par l'analyse du rendement par recrue, était de 0,76. Le taux d'exploitation courant E a été inférieur au E_{max} prédit, ce qui indique que le Kutum caspien est modérément exploité dans la partie méridionale de la mer Caspienne.

Key words. - Cyprinidae - *Rutilus frisii kutum* - Caspian Sea - Population dynamics.

Caspian Kutum, *Rutilus frisii kutum* (Kamensky, 1901) (Cyprinidae) is a major component of fish landing in the southern Caspian Sea, Iran, with extremely high market value. According to Afraei Bandpei *et al*. (2010), the number of fishermen living on Kutum fishing is 10,773 Fisherman (4,480 in Guilan, 4,800 in Mazandaran and 1,493 in Golestan). Therefore, Caspian Kutum constituted about 78% of bony fish harvest and about 76.6% of the whole income of fishermen in the 2008-2009 fishing season in the southern part of the Caspian Sea (Afraei Bandpei *et al*., 2010). The average annual catch of Caspian Kutum of the Iranian coasts was about 9,600 tonnes/year during the period 1991-2001 (FAO, 2003) and increased to 16,000 tonnes in 2006 (Shilat, 2008).

The Iranian Fisheries Organization (IFO) has been releasing up to 200 million *R. f. kutum* fry (average weight 1 g) into the rivers annually since 1982, in order to rehabilitate their reduced populations in the Caspian Sea. Stocked fry flow into the southern part of the Caspian Sea (Abdolmaleki and Ghaninejad, 2007). Caspian Kutum attains a maximum fork length of 71 cm and a maximum weight of 4 kg. Spawning migration in the rivers and the Anzali lagoon

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occurs from mid-March to mid-May, depending on water temperature, sea processes and ecological conditions (Valipour and Khanipour, 2006). Naturally, the spawning peak of *R. f. kutum* in the rivers occurs between late March and late April (Berg, 1946).

Despite its commercial importance, no studies have been carried out on the status of *R. f. kutum* populations in the southern Caspian Sea. Therefore, it is important to collect the necessary information on the niche of this target species as a tool for stock assessment, and in turn, for the sustainable management of its fisheries. Thus, the present study was carried out to investigate the population dynamics of *R. f. kutum* in the southern Caspian Sea. The main objectives of the study were to estimate the growth parameters, mortality rates, recruitment pattern, exploitation rate and relative yield per recruit. It is hoped that the results of this study will improve our understanding of population dynamics of this species.

MATERIALS AND METHODS

Study area

A sample of 1,360 Caspian Kutum, (*Rutilus frisii kutum*), representing a wide range of sizes (20-58 cm FL) was collected from the southern Caspian Sea (Fig. 1). Sampling was carried out on monthly basis, from the commercial landing of Pare fishing cooperative, which uses beach seines (1200 m long and 10-15 m high, with a cod-end bag liner of 33 mm stretched mesh size in 150 m long), from early October 2006 to mid April 2007. From May to September, fishing is banned in the southern Caspian Sea. Fork length (cm) and total weight (g) of each fish were recorded.

During the sampling period, the average surface water temperature was $14.3 \pm 5.14°C$ (Afraei Bandpei *et al.*, 2009), while salinity in the southern basin of the Caspian Sea ranges from 12 to 13‰ (Kaplin, 1995).

Growth analysis

The FISAT software (Gayanilo *et al.*, 1996) was used to analyse the length- frequency data. Growth was investigated by fitting the von Bertalanffy growth function (VBGF) to length-at-age data. The seasonalized VBGF, put forward by Pauly and Gaschütz (1979), and later modified by Somers (1988) takes the form:

$$L_t = L_\infty (1 - \exp\{-K (t - t_0)\} - (CK/2\pi\pi) \sin 2\pi\pi(t - t_s) + (CK/2\pi\pi) \sin 2\pi\pi(t_0\text{-}t_s)) \ (1)$$

where L_t is the length at time t, L_∞ the asymptotic length, K the von Bertalanffy growth coefficient, t_0 the age of fish at zero length, C the amplitude of the fluctuation in seasonal growth $(0 \leq C \leq 1)$ and t_s the commencement of variations in sinusoidal growth with respect to $t = 0$. It is valid that t_s is replaced with WP (winter point), which is equal to $t_s + 0.5$, or
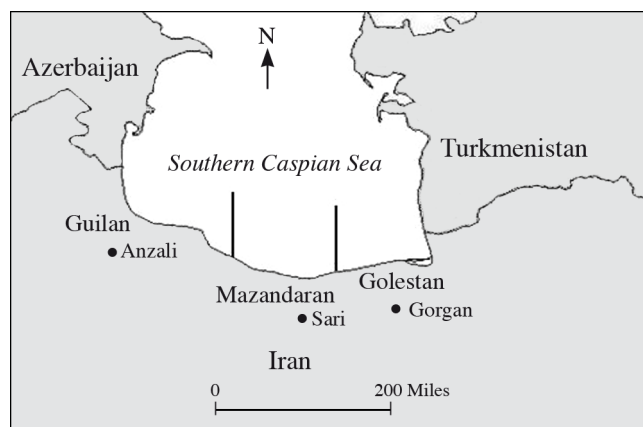

Figure 1. - Map of the Iranian waters of the Caspian Sea, showing the fishing area.

the time of the year at which growth is slowest $(0 \leq \text{WP} \leq 1)$. If seasonality is not considered (i.e., if $C = 0$), the equation reverts to the original VBGF.

The Powell-Wetherall plots (Powell, 1979) and (Wetherall, 1986) as modified by Pauly (1986) was adopted to obtain the initial estimates of L_∞ and Z/K. This method is a rearrangement of the Beverton and Holt length-based Z-equation into a linear regression of the form:

$$L^- - L' = a + bL', (2)$$

where L' is the smallest length of fully recruited fish, $L^- = [L_\infty - L'] / [1 + (Z/K)] = $ mean length of all fish $\geq L'$, where $L_\infty = -a/b$ and $Z/K = -(1 + b)/b$, a is the regression constant (intercept) and b is the regression coefficient (slope). Using the ELEFAN procedure available in FiSAT, sequentially, length-frequency data set was arranged and re-structured in order to identify the peaks, which are assumed to be cohorts.

Mortality estimate

The initial estimates of L_∞ as a starting value to obtain optimized values of VBG coefficients through the ELEFAN routine, was used to estimate the instantaneous total mortality coefficient Z based on the single negative exponential mortality model:

$$N_t = N_0 e^{-Zt} (3)$$

where N_t is the number at time t, N_0 the initial number, and Z is the instantaneous mortality coefficient.

The seasonalized length-converted catch curve (Pauly *et al.*, 1995) was used to compute Z with seasonality; thus:

$$\text{Ln}(N) = a + bt', (4)$$

where N is the number of fish in pseudo-cohorts sliced by successive growth curves, and t is the relative age of the fish in that pseudo-cohort. We also estimated Z without seasonality from the relationship (Pauly, 1984):

$$\text{Ln}(N_i / \Delta t_i) = a + bt_i, (5)$$

where N_i is the number of fish in length class i, Δt_i the time needed for the fish to grow through length class i, t_i the

relative age (computed without t_0) corresponding to the midlength of class i, and where Z without seasonality was computed from the slope b (of the descending right arm of the catch curve) with sign changed. We also computed Z using two other methods: the method of Jones ad van Zalinge (1981) and that of Beverton and Holt (1956):

$$Z = [K(L\infty - L^-)] / (L^- - L'), (6)$$

where L^- is the mean length of all fish, L' the smallest length of fully recruited fish, Z the total mortality, and K the growth coefficient.

The instantaneous natural mortality coefficient M was estimated using the empirical model of Pauly (1980):

$$Log (M) = -0.0066 – 0.279 \log (L_\infty) + 0.6543 \log (K) + 4634 \log (T) (7)$$

where T is the mean annual surface sea temperature in degrees centigrade (14.3°C in the present study).

The annual instantaneous fishing mortality coefficient (F) was calculated by subtracting the natural mortality coefficient (M) from the total mortality coefficient (Z) derived from age based catch curves ($F = Z – M$), while the exploitation rate E was estimated as F/Z.

Growth performance index

According to Pauly and Munro (1984), the growth performance index was computed from the relationship:

$$(\varphi) = 2\log L_\infty + \log K (8)$$

The potential longevity t_{max} of the species was computed from the formula:

$$T_{max} = 3/K \text{ (Taylor, 1958) (9)}$$

Probability of capture

The probability of capture P of each size class i was calculated from the ascending left arm of the length-convert-ed catch curve following the method of Pauly (1984). This entails dividing the numbers actually sampled by the expected numbers (obtained by projecting backward the straight portion of the catch curve) in each length class in the ascending part of the catch curve. By plotting the cumulative probability of capture against mid length a resultant curve was obtained, from which the length at first capture L_c was taken as corresponding to the cumulative probability at 0.5 (50%) (Etim *et al.*, 1999).

Recruitment pattern and yield per recruit

Growth parameters L_∞, K, C and WP were used as inputs, by backward projection, along a trajectory defined by the VBGF, of the frequencies onto the time axis of a time series of samples. The relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) were estimated from the Beverton and Holt model as modified by Pauly and Soriano (1986):

$$Y'/R = EU^{M/K}\{1 – (3U / 1 + m) + (3U^2 / 1 + 2m) – (U^3 / 1 + 3m)\} (10)$$

where $U = 1-(L_c/L_\infty)$ which is the fraction of growth to be completed by the fish after entry into the exploitation phase, $m = (1-E)/(M/K) = (K/Z)$, and $E (= F/Z)$ is the exploitation rate, F is the instantaneous fishing mortality coefficient and L_c is the length at first capture. The relative biomass-per-recruit (B'/R) was estimated from the relationship:

$$B'/R = (Y'/R) / F (11)$$

The two parameters F and L_c are those which can be controlled by fishery managers because F is proportional to fishing effort and L_c is a function of gear selectivity. Therefore, y'/R is considered as a function of F and L_c. Then the current value of exploitation rate (E) was used to compute E_{max} (the value of E giving the maximum y'/R), $E_{0.1}$ (the value of E at which marginal increase in y'/R is 10% of its
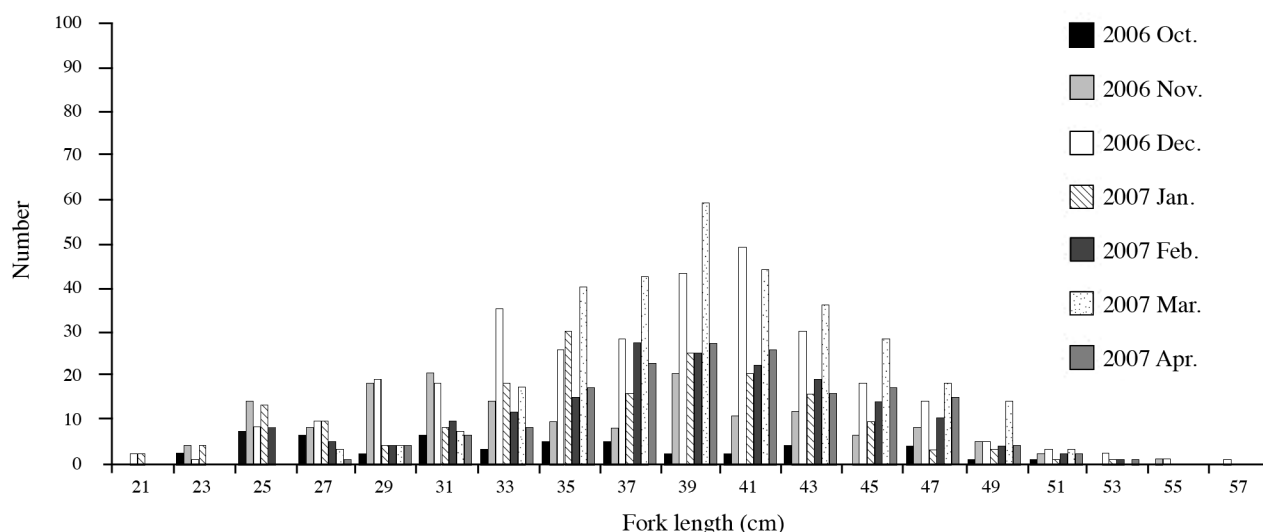

Figure 2. - Length (cm FL) frequency data of *Rutilus f. kutum* taken in the southern Caspian Sea from October 2006 to April 2007(N = 1360).
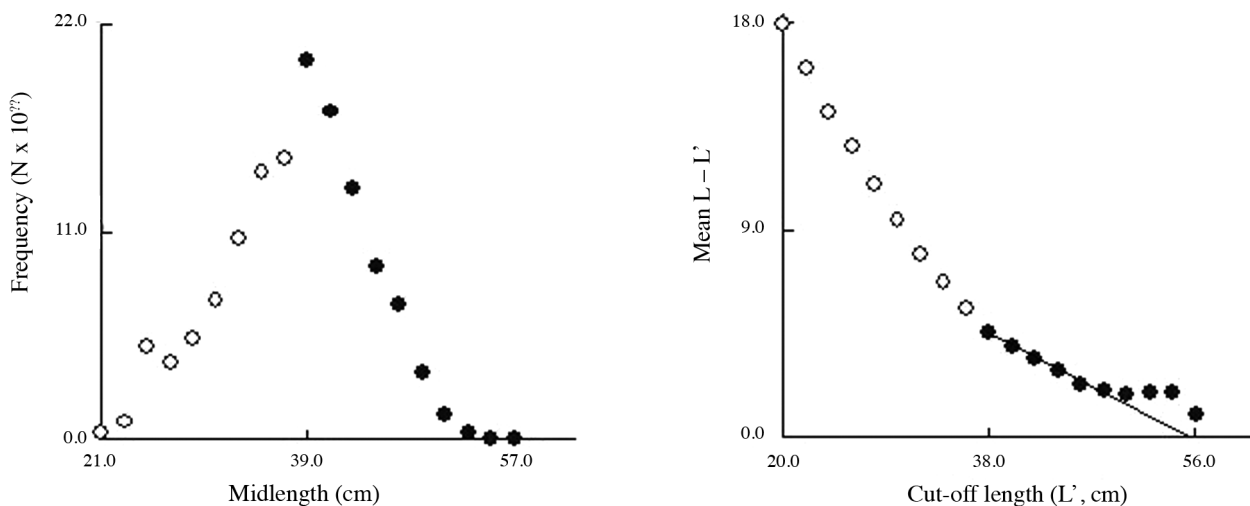
Figure 3. - Powell-Wetherall plot for *Rutilus f. kutum*. The original length frequency data are shown on the left. Black dots of the left graph were used as input in the Powell-Wetherall plot on the right. Black dots in the right graph were used for the regression analysis: $y = 14.42 - 0.260X$, $r^2 = 0.99$. $L_\infty = 55.49$ cm, and $Z/K = 2.847$.
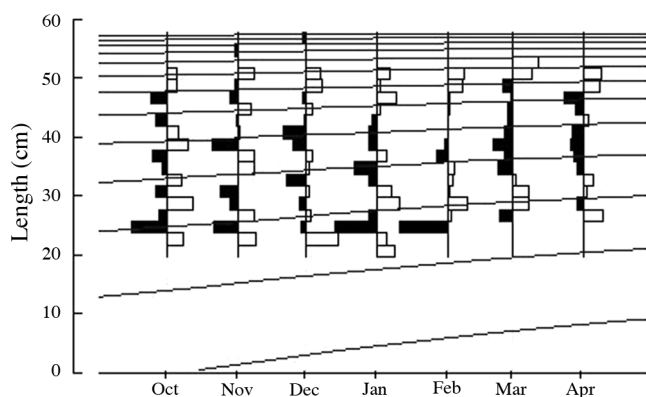

Figure 4. - Seasonalized von Bertalanffy growth curves ($L_\infty = 59.85$ cm, $K = 0.27$ yr^{-1}, $C = 0.25$, WP $= 0.40$) superimposed on the restructure length-frequency histogram of *Rutilus f. kutum* in the southern Caspian Sea. The black and white bars are positive and negative deviations from the 'weighted' moving average.

value at $E = 0$), and $E_{0.5}$ (the value of E at 50% of the unexploited relative B'/R) through the first derivative of the Beverton and Holt (1966) function.

RESULTS

Growth parameters

The field investigation covered a period of six consecutive months during the fishing season, during when we collected and measured the fork lengths of 1,360 specimens of *R. f. kutum* (Fig. 2). Estimated values of L_∞, Z/K and r^2 as obtained from the modified Powell-Wetherall plot were 55.49 cm (FL), 2.847 and 0.99, respectively (Fig. 3). The run of ELEFAN with $L_\infty = 59.85$ cm (FL) as the seeded value

produced the seasonalized growth curve depicted in figure 4 as superimposed on the re-structured length frequency histogram. The curve is characterized by the following seasonalized von Bertalanffy parameters: $L_\infty = 59.85$ cm, $K = 0.27$ y^{-1}, $C = 0.25$, WP $= 0.40$. Up to six peaks, corresponding to separate cohorts could be identified in this diagram (Fig. 4).

Mortality estimates

The length-converted catch curve procedure yielded an instantaneous total mortality coefficient $Z = 1.28$ y^{-1}, while a value of 0.910 y^{-1} was obtained from the mean length analysis (Fig. 5). Beverton and Holt method yielded $Z = 0.910$ y^{-1}, while the Jones and van Zalinge method gave a value of 4.161 y^{-1} (Fig. 6). The estimated instantaneous natural mortality rate $M = 0.46$ y^{-1}. The instantaneous fishing mortality coefficient F was 0.82 y^{-1}, giving a current exploitation rate E of 0.64 y^{-1}.

Length at first capture, gear selectivity, yield per recruitment, and recruitment pattern

The length at first capture (which is the size at which the probability of capture is 50%) was 36.8 cm in FL. This value was estimated from the plotting of the cumulative probability of capture against mid length (Fig. 7).

Computed relative yield per recruit and relative biomass per recruit were executed using two different sets of assumptions and inputs. The knife-edge procedure assumes that fishes smaller than L_c are not captured by the gear. The selection ogive approach assumes that probability of capturing any fish is proportional to its length. The knife-edge procedure (Fig. 8 (A) and (B)) revealed the following results: $E_{max} = 0.95$, $E_{0.1} = 0.81$, $E_{0.5} = 0.40$. The selection ogive pro-
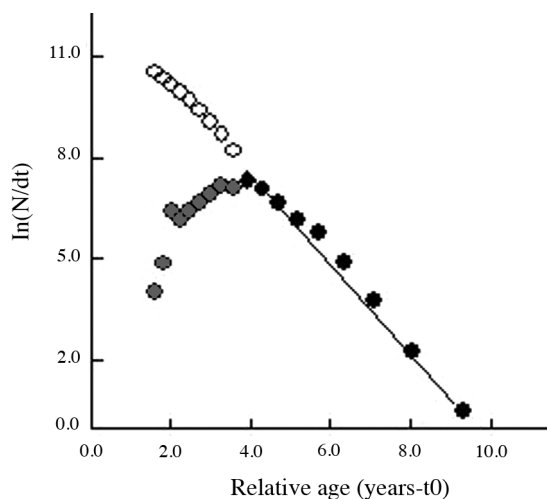
Figure 5. - Length catch curve for *Rutilus f. kutum* in the southern Caspian Sea. Regression equation for the descending right arm of the length catch curve: $y = 11.007 - 1.215X$, $n = 9$, standard deviation of $a = 0.571$ and confidence interval from 9.655 to 12.360, standard deviation of $b = 0.085$ and confidence interval $= -1.416$ to -1.013, $r^2 = 0.98$. Estimated $Z = 1.28$. Cut-off length $L' = 38$ cm, L^- (from L' up) = 43 cm.

Figure 6. - Jones and van Zalinge plot for the estimation of instantaneous total mortality coefficient Z for *Rutilus f. kutum*. Regression equation $y = -6.256 + 4.161X$, $r^2 = 0.99$, $n = 10$. Standard deviation of $a = 0.521$, confidence interval of $a = -7.457$ to -5.056. Standard deviation of $b = 0.209$, confidence interval of $b = 3.678 - 4.644$. Estimated $Z = 4.161$ yr^{-1}.
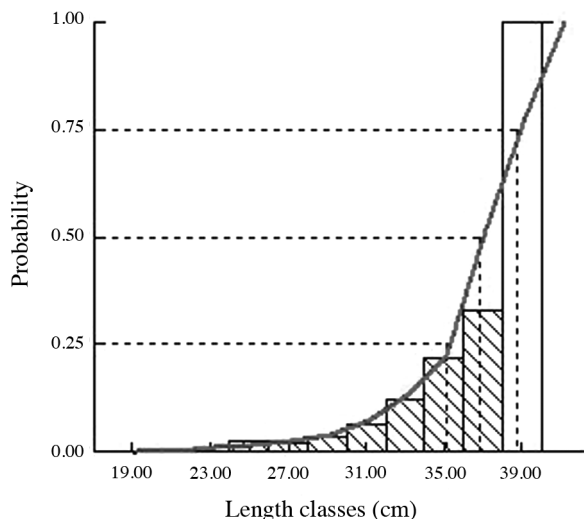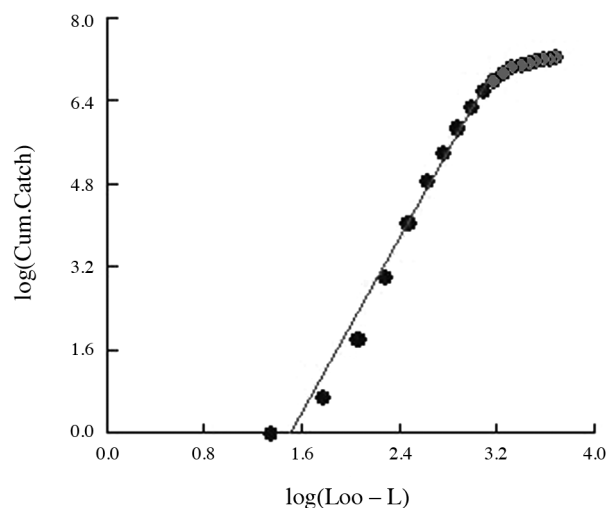

Figure 7. - Probability of capture by length class of *Rutilus f. kutum* in the southern Caspian Sea, $L_{25} = 35.2$ cm, $L_{50} = 36.8$ cm, L_c (dotted line), $L_{75} = 38.8$ cm.

cedure (Fig. 8 (C) and (D)) obtained the following values: $E_{max} = 0.76$, $E_{0.1} = 0.65$, $E_{0.5} = 0.39$. As shown in figure 9, the recruitment pattern displayed two peaks, in April (19.49%) and in August (6.33%). The longevity of the species in the Caspian Sea was estimated at 11.1 years.

DISCUSSION

Caspian Kutum, *Rutilus frisii kutum* has been described

as one of the most valuable fish species in the Caspian Sea, accounting for about 76.6% of fishermen incomes in the region (Afraei Bandpei *et al.,* 2010). It is therefore of prime importance that stocks of this fish be carefully studied in order to manage their fishery on a sustainable basis. However, to the authors' knowledge, the population dynamics of this fish in the Caspian Sea has not been studied. Therefore, the present results, apart from being seminal, may serve as a springboard for further research in this field. The present data are limited to the six- month fishing season (October-April), because fishing is officially banned from May to September in the southern Caspian Sea.

The present study revealed that the highest growth oscillation occurred in December, with six peaks. This could be due to active feeding near shore before wintering and migration to deeper waters, as has been reported by Afraei Bandpei *et al.* (2009). Those authors reported that the highest feeding activity of *R. f. kutum* occurred in November and December, while the lowest food consumption occurred in January and April.

In this study, computed values of $L_\infty = 59.85$ cm, $K = 0.27$ and $\varphi = 2.9$ for *R. f. kutum* in the southern Caspian Sea are comparable with that reported for *R. frisii* from former USSR waters (FishBase, 2008); *R. f. kutum* from Malyi Kyzylagach Bay (Abdurakhmanov, 1962) and Anzali lagoon (Ralonde and Razavi, 1972) (Tab. I). Generally, growth coefficients, φ, are species-specific parameters in which their values are usually similar within related taxa and have narrow normal distributions (Etim *et al.*, 1996). However, table I shows that K value and growth performance indices of *R. f. kutum* in the present study were different from the values reported
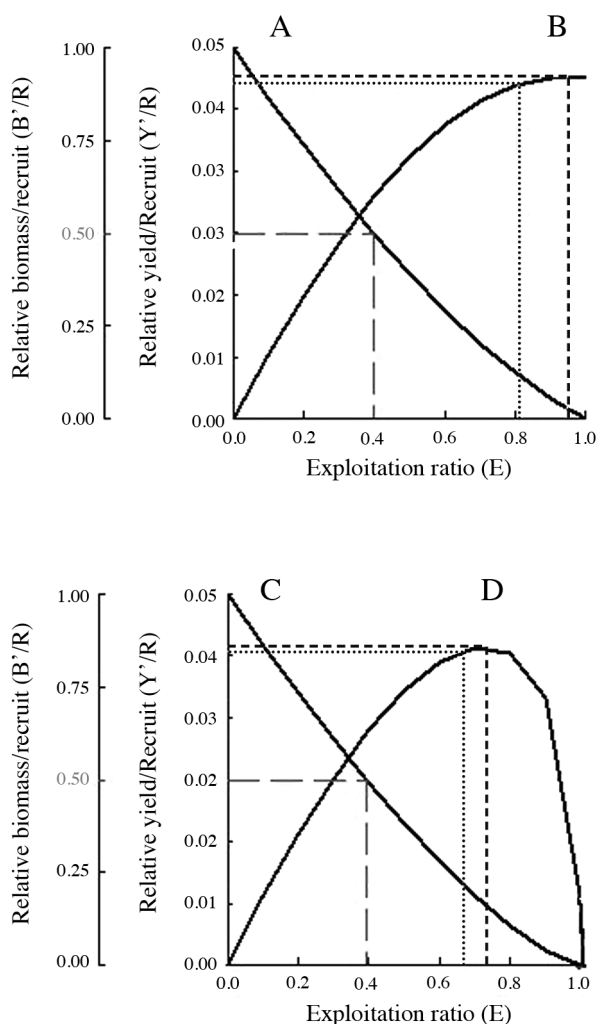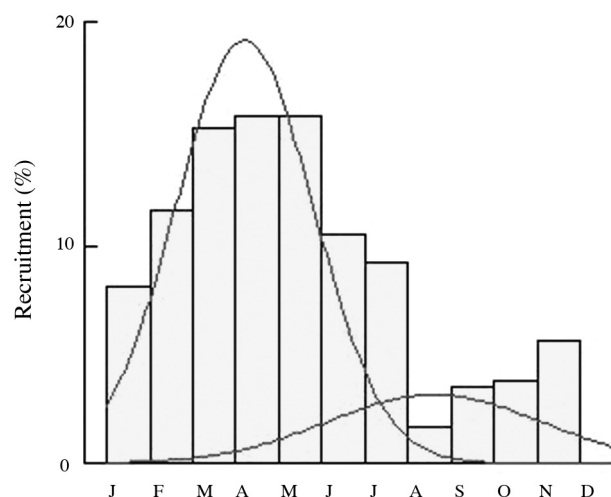
Figure 9. - Recruitment pattern of *Rutilus f. kutum* in the southern Caspian Sea obtained by backward projection, through a trajectory defined by the computed VBG coefficient of the restructure length-frequency data onto a one-year timescale.

Figure 8. - (**A**) Relative biomass per recruit and (**B**) Relative yield per recruit for *Rutilus f. kutum* as computed using knife edge selection procedure. Input parameters: $Lc/L\infty = 0.616$, $M/K = 1.70$. Output parameters: $E_{max} = 0.95$, $E_{0.1} = 0.81$, $E_{0.50} = 0.40$. (C) Relative biomass per recruit and (D) relative yield per recruit as computed using selection ogive procedure $E_{max} = 0.76$, $E_{0.1} = 0.66$, $E_{0.5} = 0.39$.

even on the same species along the southern coast areas of the Caspian Sea. This could be due to carnivorous nature and food availability for this species, ecological conditions, geographical changes and genetic variations (Afraei Bandpei *et al.,* 2009).

Branstetter (1987) categorized K value as 0.05-0.10/yr for slowly growing species, 0.10-0.20/yr for species with average growth, and 0.20-0.50/yr for rapidly growing species. Based on these criteria, *R. f. kutum* in the southern Caspian Sea are rapidly growing fish. The high growth rate of this species could be due to available food resources, ambient temperature, salinity; particularly brackish-water and freshwater in the southern coastal areas of the Caspian Sea. Afraei Bandpei *et al.* (2009) reported that *R. f. kutum* in the

southern Caspian Sea is carnivorous, and feeds on a variety of prey items. Such variations in feed selectivity could be very high especially in fish with strong seasonal growth oscillation (such as Kutum) where the value of C in eq. (1) is close to one. Therefore, differences in growth performances among areas seem to be related to the geographical conditions rather than to the methodology employed (Rico *et al.,* 2001). It is even possible that genetic relationships exist among stocks of neighboring areas. Afraei *et al.* (2006) reported that the density of fish in different areas could be related to geographic conditions.

The instantaneous total mortality coefficient (Z) calculated from length-converted catch curves, (Beverton and Holts, Jones and van Zalinge methods) often estimates with bias. In this study, the Z values of *R. f. kutum* were 1.28 yr^{-1} and 4.161 yr^{-1} based on Beverton and Hold and Jones and van Zalinge methods, respectively. It is obvious that Z is slightly underestimated by the Beverton and Holt method and grossly overestimated by the Jones and van Zalinge (1981) method.

The instantaneous natural mortality coefficient (M), apart from indicating the fraction of death caused by all possible causes except fishing, is a necessary input in the computation of many models in fish population dynamics studies, such as the relative yield per recruit and relative biomass per recruit (Eqs. 10) and (11)). In the present study, the value of M (0.46 yr^{-1}) estimated for *R. f. kutum* in the southern Caspian Sea.

The Caspian Kutum, migrate from sea to rivers for spawning in February, for three months (Holcick and Olah, 1992). However, no information is available on their recruitment. Since *R. f. kutum* are winter-spring spawners, it seems from the present results that the juveniles have a lag in time before becoming available to the fishery. However, more

Species	L_∞	K	ϕ	Author(s)
Rutilus frisii	62.2	0.40	3.19	FishBase, (2008); Former USSR
R. f. kutum	80.4	0.20	3.12	Ralonde and Razavi (1972); Anzali Lagoon
R. f. kutum	79.08	0.18	3.05	Abdurakhmanov (1962); Malyi Kyzylagach Bay
R. f. kutum	59.85	0.27	2.98	Present study; Southern Caspian Sea

Table I. - Growth parameters (L_∞ and K) and computed overall performance indices ϕ of *Rutilus f. kutum* reported by other authors.

research is needed to support this assumption.

Figure 9 showed two pulsed recruitment peaks in per year: a major peak in spring (March-May) and a minor one in autumn. However, the two peaks overlap in time to give one continues recruitment pattern. The preponderance of Kutum spwaners in the present study (specimens > 25 cm in length) may suggest a seasonal recruitment pattern reflecting the breeding activity of this species in February-May, although the main recruitment season, which coincided with the main spawning period, was from March to May with a peak in April. This could be due to the fact that spawning migration of *R. f. kutum* from Iranian Caspian Sea waters into the rivers occurs in March and April (Afraei Bandpei *et al.*, 2007). However, two cohorts of *R. f. kutum* in the present study were found. Therefore, Dadzie *et al.* (2005) concluded that identification of different cohorts based on length-frequency distribution still remains a challenge about the use of this technique in growth studies.

Etim *et al.* (1999) reported that when Z/K ratio < 1 the population is growth-dominated; when the value is > 1 the population is mortality-dominated; when it equals 1, then mortality balances growth. In the present study, Z/K value was 2.847 (Fig. 3), indicating a high level of exploitation.

The yield per recruit analysis via the knife-edge selection gave an E_{max} of 0.95. Using the more realistic selection ogive procedure, the yield per recruit gave an E_{max} of 0.76. The current exploitation rate E of 0.64 was less than the predicted E_{max}. These results suggest that *R. f. kutum* stock in southern Caspian Sea is not overexploited, but rather moderately exploited. This could be due to the stocking of about 200 millions of hatchery-reared Kutum fry into the Caspian Sea annually since 1982 (Shilat, 2008).

Figure 7 shows that the optimum fishing activity, both in terms of fishing effort and size at first capture, was 36.8 cm FL, and the exploitation rate was 0.64. Based on the critical size ratio (L_c/L_∞) (which is a proxy to mesh size) and current exploitation rate (E) (which is a proxy to effort), Pauly and Soriano (1986) reported that relative yield isopleths derived from Equation (10) could be grouped into four categories, each with its distinct properties. In this study, the $Lc/L_\infty = 0.614$ and $E = 0.64$, where the yield isopleth falls into quadrant D. This finding indicates that the mesh size of the fishing nets is not harmful to small fish, since younger fish have a chance to escape from the wings of the net before getting trapped in the bag net which has a smaller mesh size (33 mm) than that in the wings (36, 40, 45, and 50 mm) of the nets (Ghadirnejad, 1996). The social goals such as optimizing the net profit of the fishery to the society, enhancing the economic status of the community and maximizing employment in the fishery are some policy objectives that must be taken into account in adopting any management strategy. Yield per recruit analysis suggests that the stock is not yet overexploited.

It has been reported that fish lifespan is directly related to genome size, where fish age increases in fish with large genomes (Griffith *et al.*, 2003). In the present study, the maximum age of *R. f. kutum* was 11.1 years. This age is in close agreement with the results of Wheeler (1992) who reported that the maximum age of *R. frisii*. is about 12 years.

In conclusion, this study showed that the mean length at first capture of *R. f. kutum* in the Caspian Sea was 36.8 cm FL, and this species has a growth performance index slightly higher than other species. yield per recruit analysis suggests that Kutum stock is moderately exploited. The main recruitment season coincides with the main spawning period; however, further research is needed to complete the study of recruitment pattern, particularly from May to September.

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